

Air Leakage Sealing - Materials and Techniques

Air leakage is a major problem for both new and existing homes and can:

- ❑ Contribute 30 percent or more to heating and cooling costs
- ❑ Create comfort and moisture problems
- ❑ Draw in pollutants such as radon and mold
- ❑ Serve as a prime entry for insects and rodents

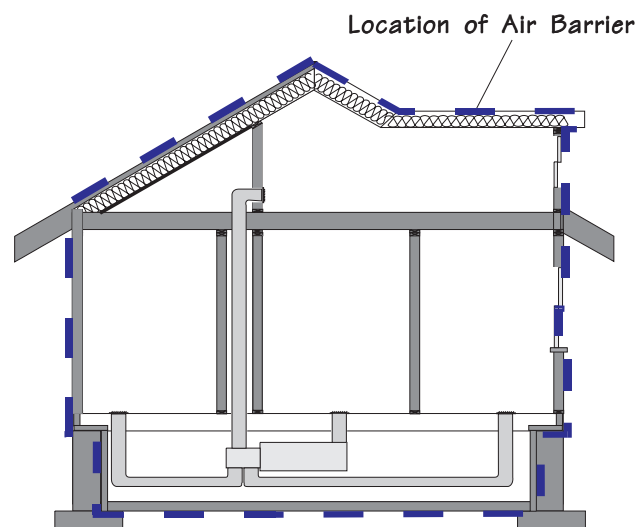
To reduce air leakage effectively requires a *continuous air barrier system (sometimes called an air retarder system)* — a combination of materials linked together to create a tight building envelope. An air barrier also minimizes air currents through insulation, helping maintain R-values. The air barrier should minimize air leakage through the building envelope — the boundary between the conditioned portion of the home and the unconditioned area.

Most standard insulation products are not effective at sealing air leakage. The R-value for these materials may drop if air leaks through the material. Some spray-applied insulation materials, such as higher density fiberglass, rock wool, cellulose, and foam can seal against air leakage. However, these materials are often only applied in framing cavities; therefore, additional air sealing must be done between framing components.

The builder should work with his or her own crew and subcontractors to seal all holes through the envelope. Then, he or she should install a continuous air barrier material, such as drywall or housewrap, around the envelope. It is critical in the air sealing process to use durable materials and install them properly.

The air barrier constitutes the pressure boundary of the home as discussed in Chapter 3. The pressure, moisture, and thermal boundaries should coincide; otherwise, cold winter air may leak past the insulation, or water vapor may enter an uninsulated space where it encounters building materials below their dew point. Always draw sections of your home similar to Figure 4-1 in order to locate the pressure boundary distinctly.

Figure 4-1
Creating a Pressure Boundary



1. Install continuous insulation
2. Seal penetrations and bypasses
3. Install and seal air barrier material

AIR LEAKAGE DRIVING FORCES

Air leakage requires two main ingredients:

- ❑ Holes — the larger the hole, the greater the air leakage. Large holes have higher priority for air sealing efforts.
- ❑ Driving force — a pressure difference that forces air to flow through a hole. Holes that experience stronger and more continuous driving forces have higher priority. The common driving forces are:
 - *wind* -- caused by weather conditions
 - *stack effect* -- upward air movement of warmer air
 - *mechanical blowers* -- induced pressure imbalances caused by operation of fans and blowers

Wind is usually considered to be the primary driving force for air leakage. When the wind blows against a building, it creates a high pressure zone on the windward areas. Outdoor air from the windward side infiltrates into the building while indoor air exits on the leeward side. Wind acts to create areas of differential pressure which causes both infiltration and exfiltration. The degree to which wind contributes to air leakage depends on its velocity and duration.

The temperature difference between inside and outside causes warm air inside the home to rise while cooler air falls, creating a driving force known as the *stack effect*. The stack effect is fairly weak but is almost always present. Most homes have large holes leading into the attic and crawlspace or basement. Because the stack effect is so prevalent and the holes through which it drives air are often so large, it is usually a major contributor to air leakage, moisture, and air quality problems.

Forced-air heating and cooling systems that are either poorly designed or installed can create three types of driving forces for air leakage:

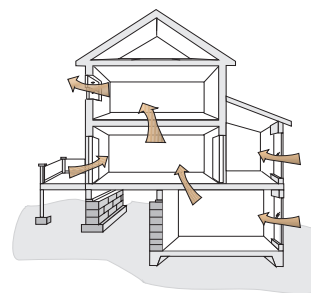
- ❑ Suction pressures that pull outside air into return duct leaks.
- ❑ HVAC blower drives heated or cooled air out of the supply ductwork to the exterior.
- ❑ Duct-related problems can create pressure imbalances in the home that increase air leaks through holes in the pressure boundary

Figure 4-2
Wind Driven Infiltration



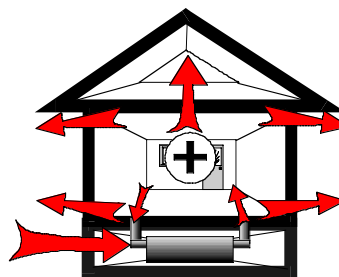
On average, wind in the Southeast creates a pressure difference of 10 to 20 Pascals on the windward side. However, most homes have only small cracks on the exterior, and winds are variable.

Figure 4-3
The Stack Effect



The stack effect can create pressure differences between 1 to 3 Pascals due to the power of rising warm air. Crawlspace and attic holes are often large.

Figure 4-4
Mechanical System Driven Infiltration



Leaks in supply and return ductwork can cause pressure differences of up to 30 Pascals. Exhaust equipment such as kitchen and bath fans and clothes dryers can also create pressure differences.



MEASURING AIRTIGHTNESS WITH A BLOWER DOOR

While there are many well known sources of air leakage, virtually all homes have unexpected air leakage sites called *bypasses*. These areas can be difficult to find and correct without the use of a *blower door*. This diagnostic device consists of a temporary door covering installed in an outside doorway and a fan which pressurizes (forces air into) or depressurizes (forces air out of) the building. When the fan operates, it is easy to feel air leaking through cracks in the building envelope. Blower doors have gauges which measure the building's air leakage rate.

One measure of a home's leakage rate is air changes per hour (ach), which estimates how many times in one hour the entire volume of air inside the building leaks outside. To determine the number of air changes per hour, many experts use the blower door to create a negative pressure of 50 Pascals. A *Pascal* is a small unit of pressure — about 0.004 inches water gauge. A quarter resting on your hand exerts over 120 Pascals. Fifty Pascals is approximately equivalent to a 20 mile-per-hour wind. Energy efficient builders should strive for less than four air changes per hour when testing their home at 50 Pascals pressure (4 ACH50). The rate of natural air changes per hour (nach) can be estimated from the ACH50 and certain characteristics of the home.

Some building scientists use a different criterion — the air leakage rate per square foot of exterior envelope (CFM50/ sq ft). The goal is often 0.30 CFM50/ sq ft or less. An expert blower door technician can perform more advanced tests to find major sources of air leakage.

Table 4-1
Typical Infiltration Rates
(in air changes per hour -- ach)

| | ACH50 (blower door test result) | nach (natural rate) |
|------------------------------------------------------------------------------|---------------------------------------|------------------------|
| New home with special airtight construction and controlled ventilation | 0.5 - 2.5 | 0.03 to 0.15 |
| Home with air barrier | 3.0 - 5.0 | 0.15 to 0.3 |
| Standard new home | 7.0 - 15.0 | 0.4 to 1.0 |
| Standard existing home | 10.0 - 25.0 | 0.5 to 1.3 |
| Older, leaky home | 20.0 - 50.0 | 1.0 to 3.0 |

Figure 4-5
Blower Door

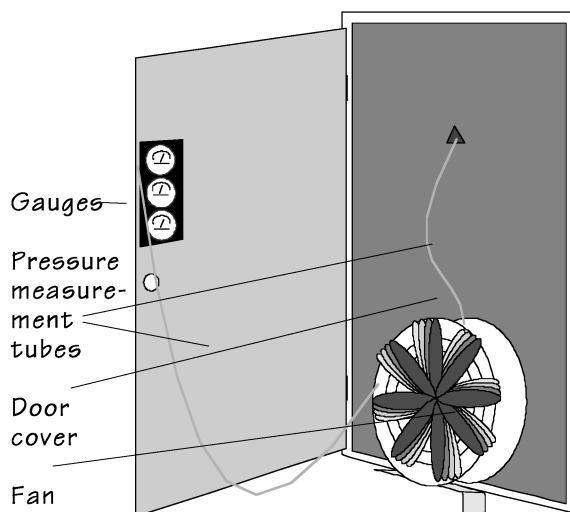
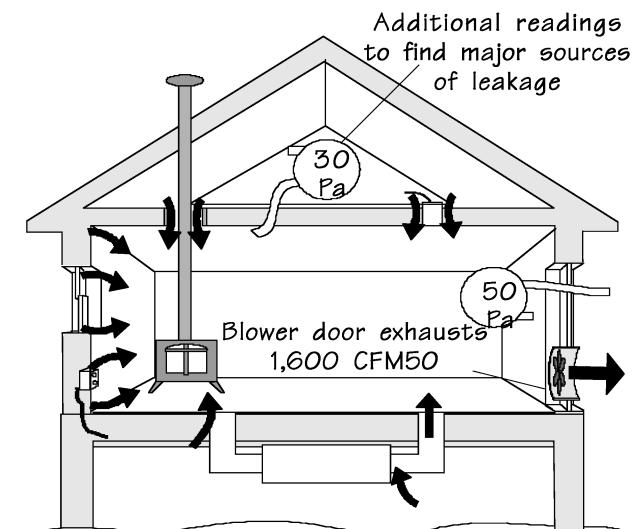


Figure 4-6
Home Blower Door Test



If the house has:
Volume of 16,000 cubic feet and
1,600 CFM50 (cubic feet per minute at 50 Pascals);
the ACH50=

$$\frac{1,600 \text{ CFM} \times 50 \times 60 \text{ minutes/hour}}{16,000 \text{ Volume of house}} = 6 \text{ ACH50}$$

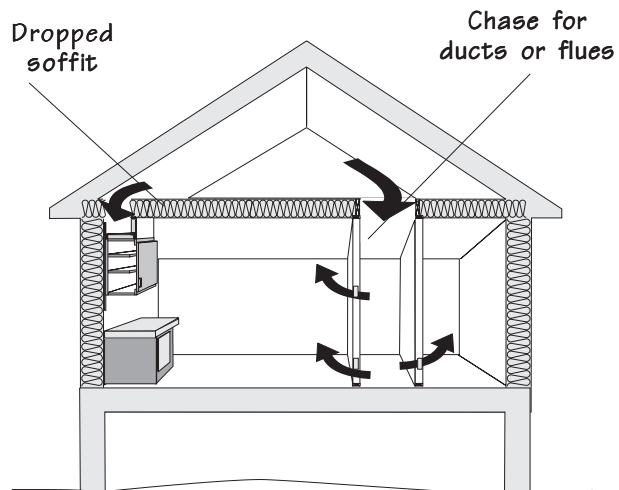
MATERIALS

Most air barrier systems rely on a variety of caulks, gaskets, weatherstripping, and sheet materials, such as plywood, drywall, and housewraps. The extra cost of these materials is usually under \$500 for standard house designs. Polyethylene can serve as an air barrier in addition to a vapor barrier; however, interior vapor barriers are not recommended for most homes in Louisiana.

SEAL PENETRATIONS AND BYPASSES

The first step for successfully creating an air barrier system is to seal all of the holes in the building envelope. Too often, builders concentrate on air leakage through windows and doors and ignore areas of much greater importance. Many of the key sources of leakage — called *bypasses* — are hidden from view behind soffits over cabinets, bath fixtures, dropped ceilings, as well as chases for flues and ductwork, as shown in Figure 4-7. Attic access openings and whole house fans are also common bypasses. Sealing these bypasses is critical to reduce air leakage and maintain the performance of insulation materials.

Figure 4-7
Air Leakage Through Bypass



Figures 4-8, 4-9, and 4-10 show key areas that must be sealed to create an effective air barrier. The builder must clearly inform his or her subcontractors and workers of these details to ensure that the task is accomplished successfully. Make certain all sealants have at least 40-year service lives.

Table 4-2
Leaks and Sealants

| Type of Leak | Commonly Used Sealants |
|--------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Thin gaps between framing and wiring, pipes or ducts through floors or walls | 40-year caulking; one-part polyurethane is recommended. |
| Leaks into attics, cathedral ceilings, wall cavities above first floor | Firestop caulking. |
| Gaps, or cracks or holes over 1/8 inch in width not requiring firestop sealant | Gasket, foam sealant, or stuffed with fiberglass or backer rod, and caulk on top. |
| Open areas around flues, chases, plenums, plumbing traps, etc. | Attach and caulk a piece of plywood or foam sheathing material that covers the entire opening. Seal penetrations. If a flue requires a noncombustible clearance, use a noncombustible metal collar, sealed in place, to span the gap. |
| Final air barrier material | Use Airtight Drywall Approach, continuous housewrap, or other air barrier system. |

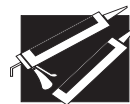
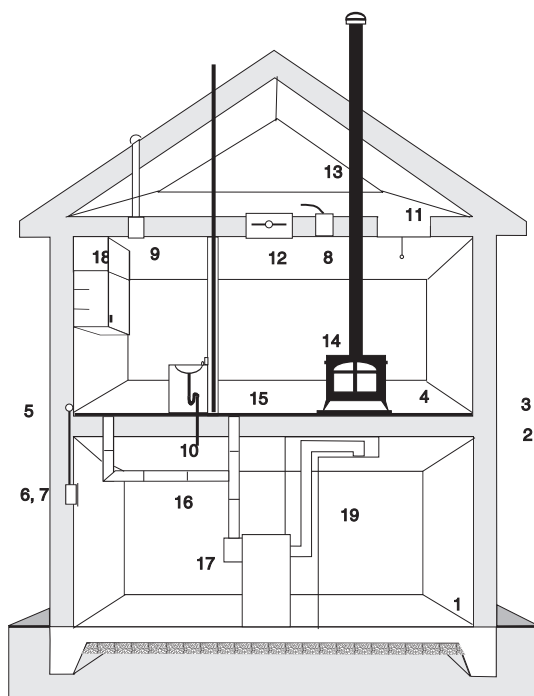
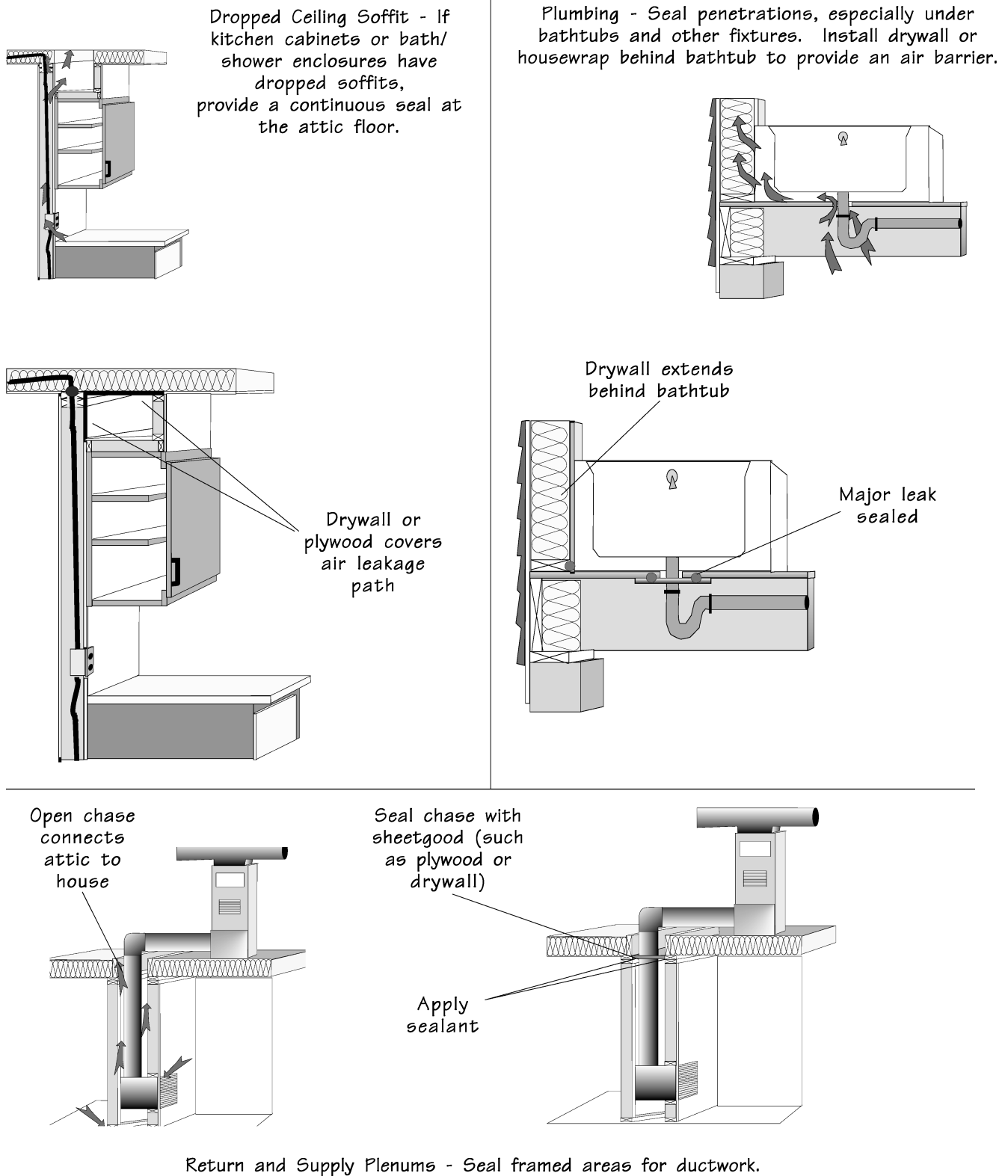


Figure 4-8
Typical Home Air Leakage Sites



1. *Slab Floors* — seal all holes in the slab to prevent entry of water vapor and soil gas. A 4- to 6-inch layer of gravel under the slab is important to stop the seepage of water by capillary action.
2. *Sill Plate and Rim Joist* — seal all sill plates above basements and unvented crawlspaces. Seal rim or band joists between floors in multi-story construction with caulking or gaskets.
3. *Bottom Plate* — use caulk or gasket between the plate and subflooring.
4. *Subfloor* — use an adhesive to seal the seams between pieces of subflooring.
5. *Electrical Wiring* — use wire-compatible caulk or spray foam to seal penetrations.
6. *Electrical Boxes* — use approved caulk or tape to seal around wiring holes of electrical boxes. Seal between the interior finish material and boxes.
7. *Electrical Box Gaskets* — caulk foam gaskets to all electrical boxes in exterior and interior walls before installing coverplates.
8. *Recessed Light Fixtures* — consider using surface-mounted light fixtures rather than recessed lights. When used, specify airtight models rated for insulation coverage (IC).
9. *Exhaust Fans* — seal between the fan housing and the interior finish material. Choose products with tight-fitting backdraft dampers.
10. *Plumbing* — locate plumbing in interior walls, and minimize penetrations. Seal all penetrations with foam sealant or caulk.
11. *Attic Access* — weatherstrip attic access openings. For pull-down stairs, use latches to hold the door panel tightly against the weatherstripping. Cover the attic access opening with an insulated box.
12. *Whole House Fan* — use a panel made of rigid insulation or plastic to seal the interior cover or a box made from duct board to seal on top.
13. *Flue Stacks* — install a code-approved flue collar and seal with fire-rated caulk.
14. *Combustion Appliances* — closely follow local codes for firestopping measures, which reduce air leakage as well as increase the safety of the appliance. Make certain all combustion appliances, such as stoves, inserts, and fireplaces, have an outside source of combustion air and tight-fitting dampers or doors.
15. *Return and Supply Registers* — seal all boots connected to registers or grilles to the interior finish material.
16. *Ductwork* — seal all joints in supply and return duct systems with mastic.
17. *Air Handling Unit* (for heating and cooling system) — seal all joints and holes with mastic. Seal service panels with tape.
18. *Dropped Ceiling Soffit* — use sheet material such as drywall and sealant to stop leaks from attic into the soffit or wall framing; then insulate.
19. *Chases* (for ductwork, flues, etc.) — prevent air leakage through these bypasses with sheet materials and sealants.

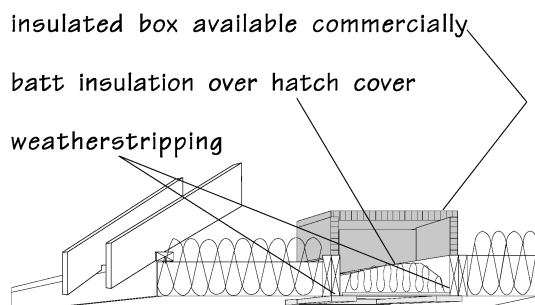
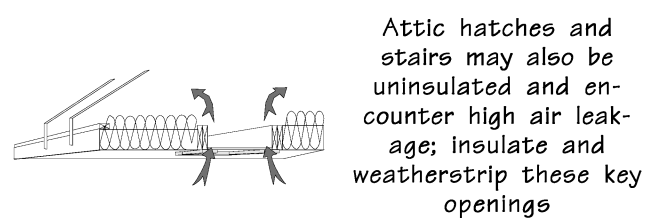
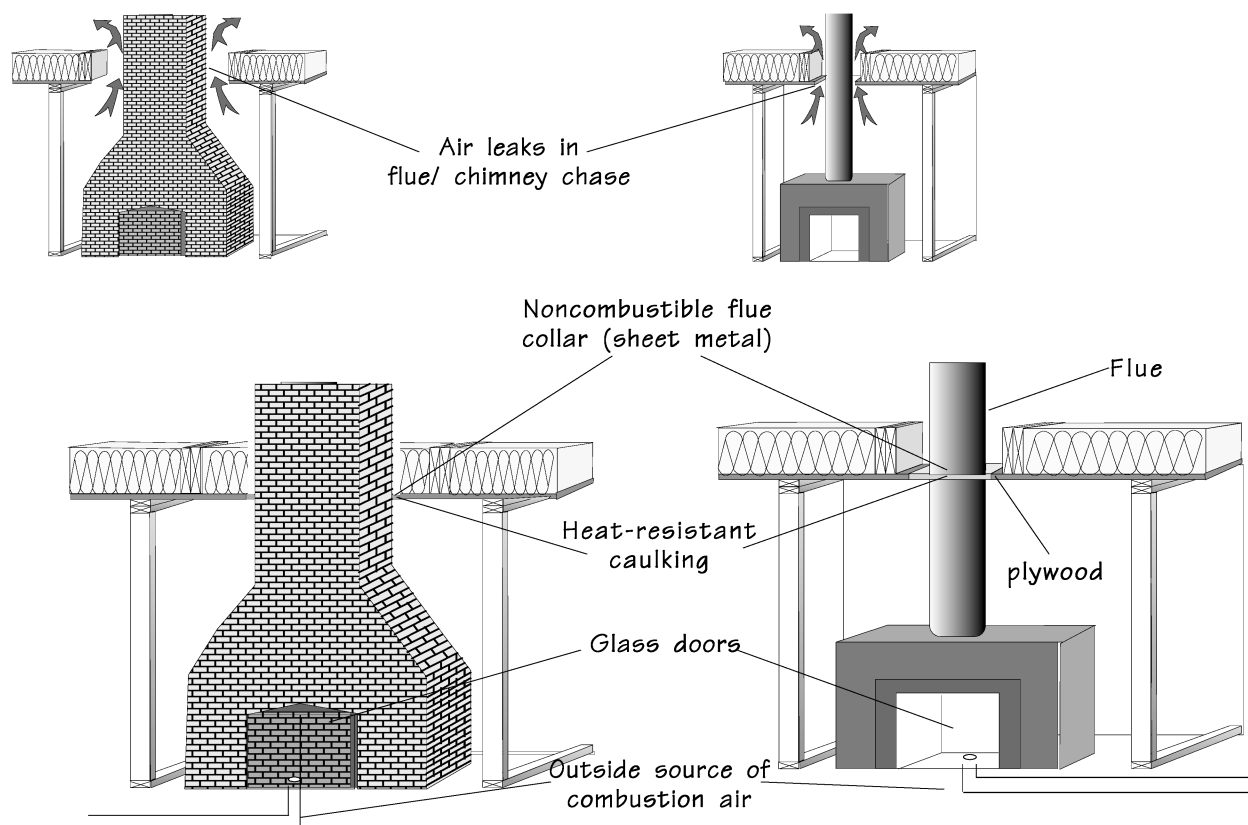
Figure 4-9
Sealing Bypasses





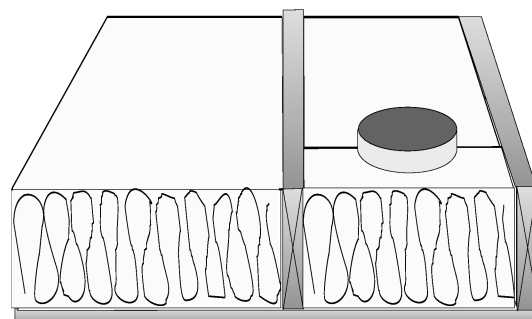
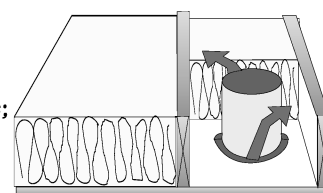
**Figure 4-10
Sealing More Bypasses**

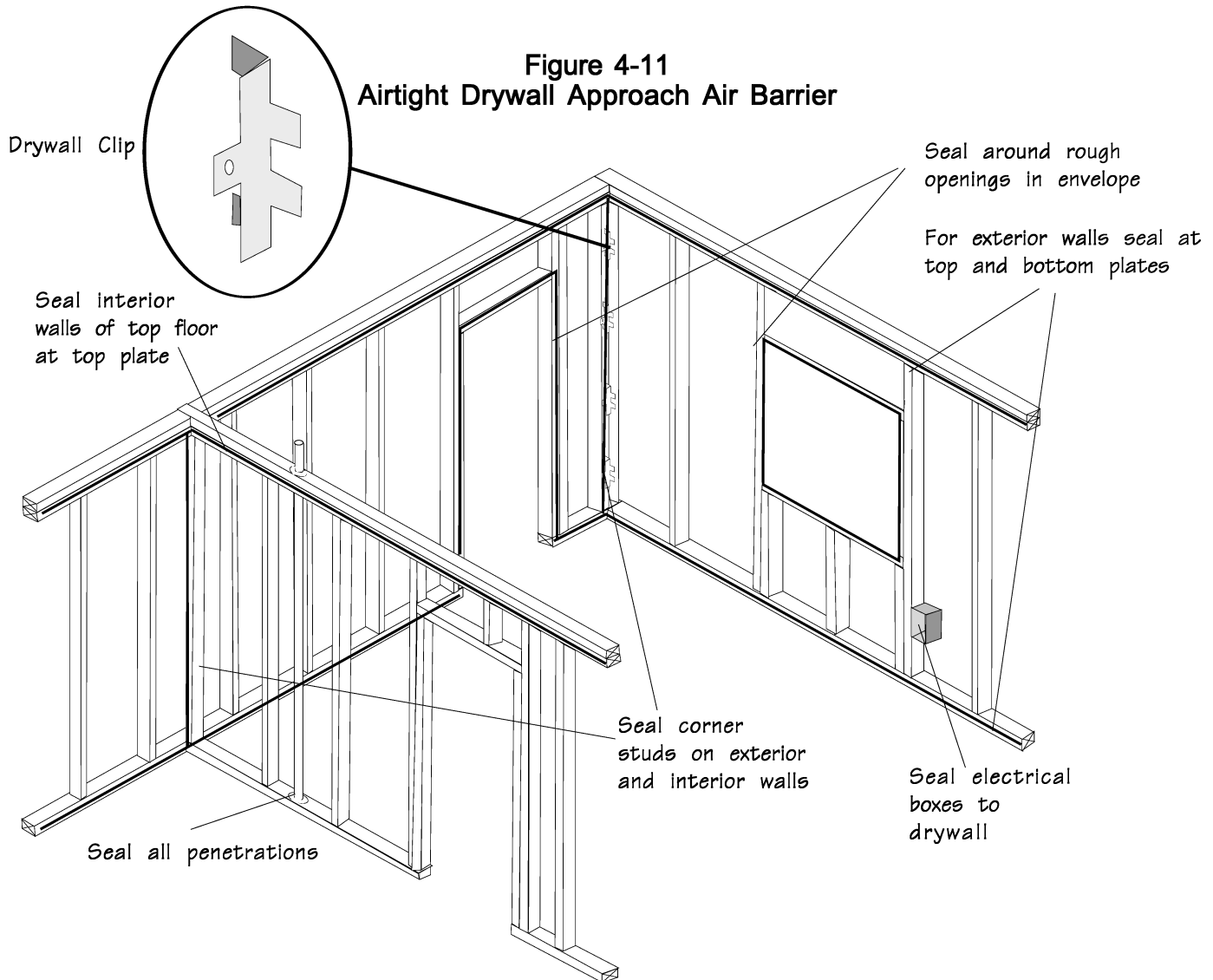
Chases - Framed chases for flues should be sealed at the attic floor. Use a continuous layer of plywood or other solid sheet good. Seal between the flue and combustible materials with fire-rated caulk and a noncombustible flue collar.



Or install outside the conditioned space

Standard recessed lights cannot be insulated and suffer substantial air leakage; install IC (insulated cover), air tight recessed fixtures





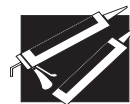
AIRTIGHT DRYWALL APPROACH

The Airtight Drywall Approach (ADA) is an air sealing system that connects the interior finish of drywall and other building materials together to form a continuous barrier. ADA has been used on hundreds of houses and has proven to be an effective technique to reduce air leakage as well as keep moisture, dust, and insects from entering the home.

In a typical drywall installation, most of the seams are sealed by tape and joint compound. However, air can leak in or out of the home in the following locations:

- ☐ Between the edges of the drywall and the top and bottom plates of exterior walls
- ☐ From the attic down between the framing and drywall of partition walls
- ☐ Between the window and door frames and drywall
- ☐ Through openings in the drywall for utilities and other services

ADA uses either caulk or gaskets to seal these areas and make the drywall a continuous air barrier system. ADA gaskets are pliable materials with "memory" -- when compressed and then released by drywall that is shrinking and expanding, they quickly return to their previous position. The gaskets can be applied long before the drywall crew arrives -- just make sure they do not remove the gaskets.



ADA Advantages

Effective — ADA is a reliable air barrier.

Simple — does not require specialized subcontractors or unusual construction techniques. If gasket materials are not available locally, they can be shipped easily.

Does not cover framing — the use of ADA does not prevent the drywall from being glued to the framing.

Scheduling — gaskets can be installed anytime between when the house is “dried-in” and the drywall is attached to framing.

Adaptable — builders can adapt ADA principles to suit any design and varying construction schedules.

Cost — materials and labor for standard designs should only cost \$100-\$300.

ADA Disadvantages

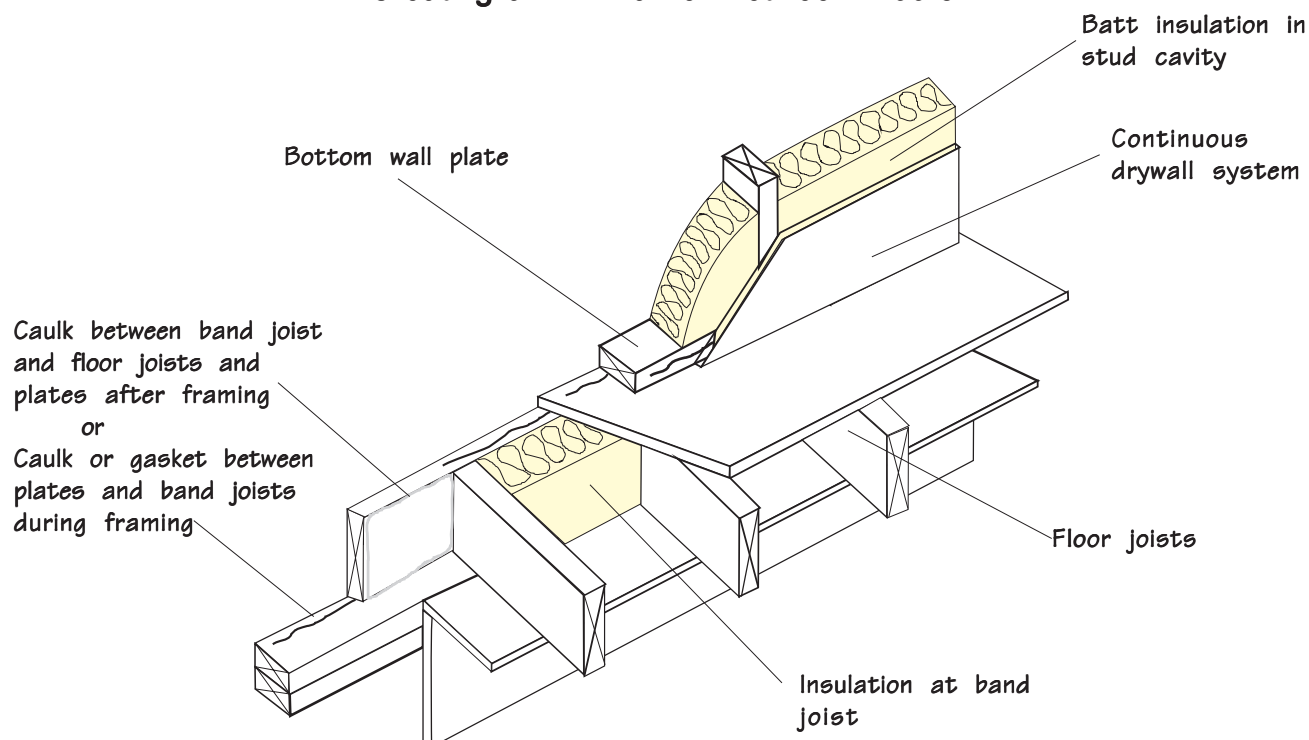
New — although ADA is a proven technique, many building professionals and code officials are not familiar with its use.

Not a vapor barrier — if required, a separate vapor barrier must be used with ADA. However, faced insulation batts, polyethylene plastic, or vapor retarder paint work well.

Requires thought — while ADA is simple, new construction techniques require careful planning to ensure that the air barrier remains continuous. However, ADA is often the most error-free and reliable air barrier for unique designs.

Requires care — gaskets and caulking can be damaged or removed by subcontractors when installing the drywall or utilities.

Figure 4-12
Creating an Air Barrier Between Floors



ADA Installation Techniques

Wood framed floors

- ☐ Seal seams in and around the band joist to minimize air leakage.
- ☐ For unvented crawlspaces or basements, seal beneath the sill plate.
- ☐ Seal the seams between pieces of subflooring with good quality adhesive.

Slab floors

- ☐ Seal expansion joints and penetrations with a sealant such as one-part urethane caulk.

Windows and doors

- ☐ Seal drywall edges to either framing or jambs for windows and doors.
- ☐ Fill rough opening with dry foam gasket or non-expanding caulk, spray foam sealant, or suitable substitute.
- ☐ Caulk window and door trim to drywall with clear or paintable sealant.

Exterior framed walls

- ☐ Seal between the bottom plate and subflooring with caulk or gaskets.
- ☐ Install ADA gaskets or caulk along the face of the bottom and top plate so that when drywall is installed it compresses the sealant to form an airtight seal against the framing.
- ☐ Use drywall joint compound or caulk to seal the gap between drywall and electrical boxes; install foam gaskets behind coverplates and caulk holes in boxes.

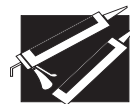
- ☐ Homes in Louisiana do not need an interior vapor barrier - sealing air leaks is more effective at moisture control .
- ☐ Seal penetrations through the top and bottom plates for plumbing, wiring, and ducts; local fire codes may require firestopping for leaks through top plates.

Partition walls

- ☐ Seal the drywall to the top plate of partition walls with attics and other unconditioned spaces above.
- ☐ Install gaskets or caulk on the face of the first stud in the partition wall. Sealant should extend from the bottom to the top of the stud to keep air in the outside wall from leaking inside.
- ☐ Seal the ductwork where it projects through partition walls.
- ☐ Seal penetrations through the top and bottom plates for plumbing, wiring, and ducts.

Ceiling

- ☐ Seal openings for chases and dropped soffits.
- ☐ Follow standard finishing techniques to seal the junction between the ceiling and walls.
- ☐ When installing ceiling drywall, do not damage ADA gaskets, especially in tight areas such as closets and hallways.
- ☐ Seal all penetrations in the ceiling for wiring, plumbing, ducts, attic access openings, and whole house fans.
- ☐ Avoid recessed lights; where used, install airtight, IC-rated fixtures and caulk between fixtures and drywall.



HOUSEWRAP AIR BARRIERS

Housewrap materials can reduce air leaks through exterior walls if installed properly. They are advantageous in Louisiana because they are permeable to water vapor, thus helping prevent moisture build-up in walls.

One of the major problems with housewraps has been their relatively poor field installation. In fact, many homes with exterior housewraps do not reap the full energy savings because of subpar installation. To stop air leakage, the housewrap material must be sealed to the framing, and all penetrations and seams must be sealed as well.

Housewrap Advantages

Air barrier — housewrap allows water vapor to pass through.

Availability — housewraps have been used for years in homes and are usually available in local building supply houses.

Installation — housewraps require no special tools and can be installed in large sheets with relatively few joints. Tears can be repaired with approved tapes.

Cost — materials and labor for completely air sealing standard home designs should only cost a few hundred dollars.

Marketing — the visibility of housewraps help advertise the home as "energy efficient".

Housewrap Disadvantages

Sealing penetrations and seams — it can be difficult to seal housewraps to plumbing, wiring, and ducts; between overlapped seams; and at the junctions between floors, walls and ceilings. Many standard caulks do not provide an effective, long-term seal, so select products with 30 to 50-year guarantees.

Connection to floor and ceiling--housewraps can seal leaks through exterior walls, but the builder must take care to connect and seal the product to ceiling and floor assemblies.

Figure 4-13
Housewrap-Window Connection

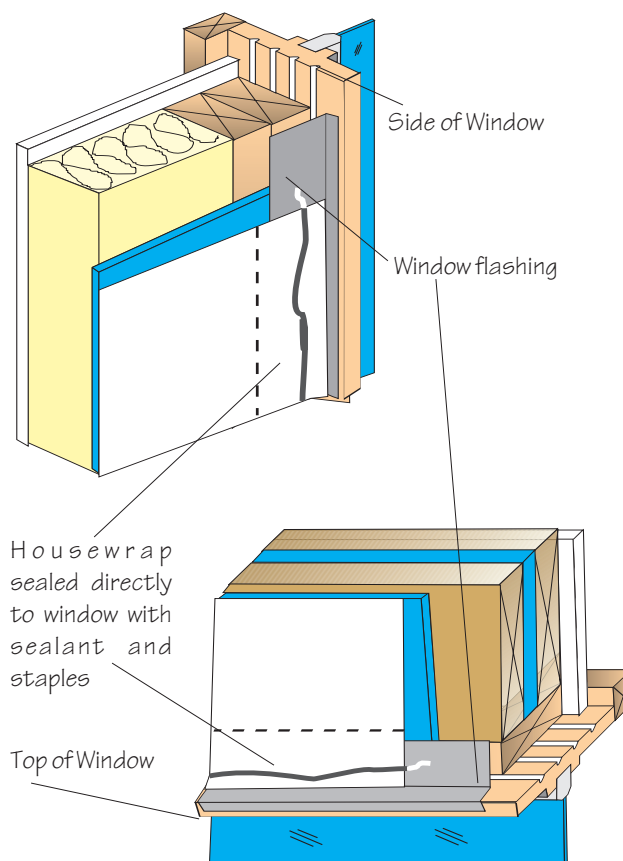


Figure 4-14
Sealing Seams in Housewrap

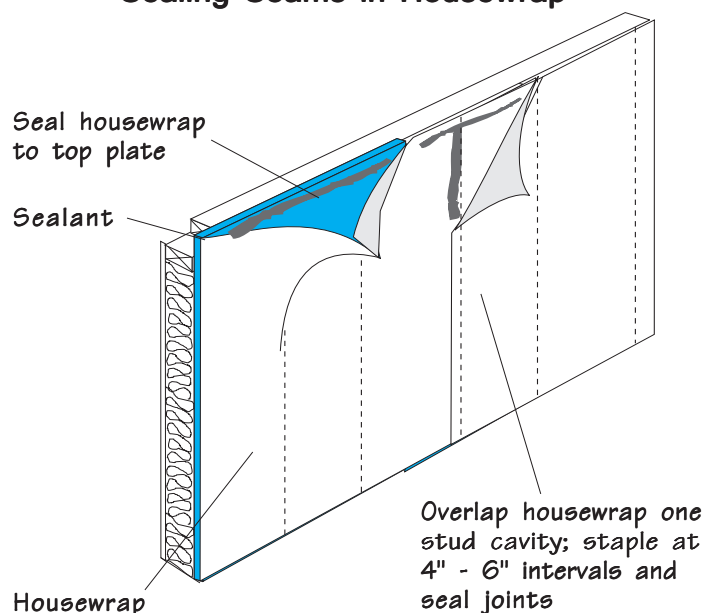


Figure 4-15
Recommended Housewrap
Installation Process & Procedures

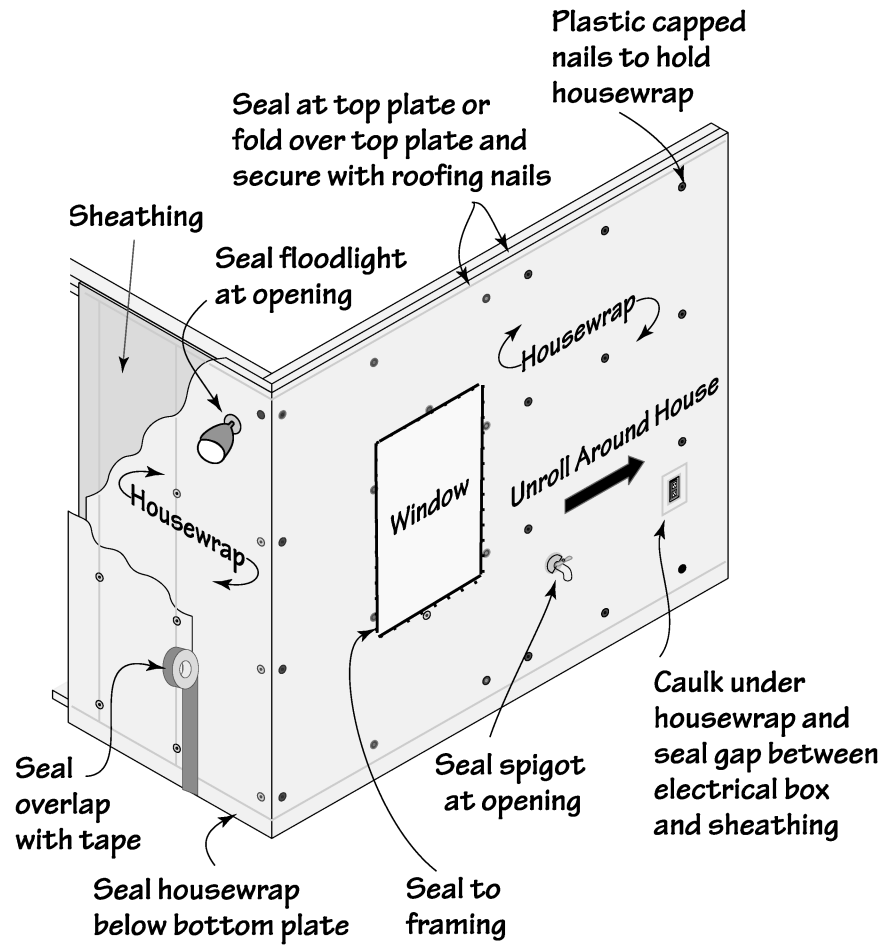
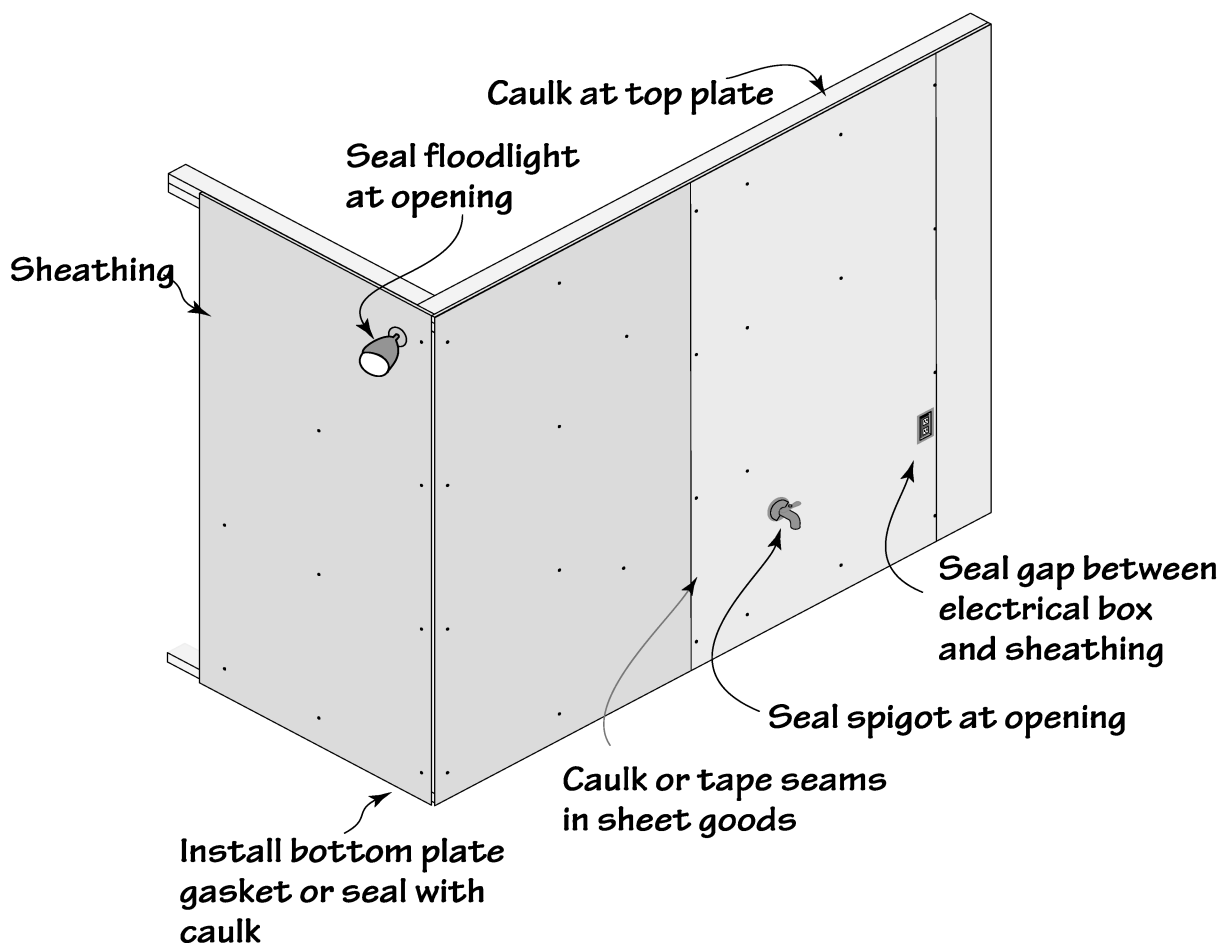




Figure 4-16
Sealing Sheathing as Exterior Air Barrier



Foam Sheathing Barrier

Foam exterior sheathing can serve as both insulation and an exterior drainage. Detailing is, of course, critical especially at joints and penetrations. All seams should be sealed, as shown in Figure 4-16. Horizontal seams must be flashed with Z-flashing or comparable sealants.

The exterior sheathing material can either serve as a moisture shedding/ air sealing membrane, or as a moisture absorbing surface that may contribute to the degradation of the building envelope. The keys to having a beneficial sheathing surface are:

- ❑ Either avoid or protect sheathing materials that will degrade, such as OSB, plywood, and exterior drywall.

- ❑ Always lap protective materials such as housewrap and exterior felt higher over lower (shingle style) to shed water.
- ❑ Do not use tape to seal horizontal seams, install flashing instead.
- ❑ Provide moisture and vapor a place to escape — a drain for moisture and a vent for vapor.

Of course, it is important in Louisiana to allow the wall to dry — usually by eliminating the interior vapor barrier and letting water vapor inside the wall cavity move into the air conditioned home. Therefore, avoid the use of vinyl wallpapers and other interior vapor barrier materials.

Notes: